Science Journal of Agricultural Research and Management
ISSN: 2276-8572
http://www.sjpub.org

Published By
Science Journal Publication
International Open Access Publisher

Research Article **Volume 2012, Article ID sjarm-174, 4 Pages, 2012. doi: 10.7237/sjarm/174**

Small-scale Fisheries and Conservation of Dusky Grouper (Garoupa), Epinephelus marginatus (Lowe, 1834) in the Southeastern Brazilian Coast

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Accepted 24 May, 2012

Abstract-The dusky grouper (garoupa), *Epinephelus marginatus*, is highly valued in Brazil as a commercial fish species harvested by small-scale fishermen. This protogynous and slow-growing species is caught at immature stages by fishermen. We propose urgent conservation measures, including compensatory arrangements, to encourage fishermen to conserve this species. Closed fishing seasons associated with compensatory arrangements could help towards the conservation of this highly threatened fish, which has been ignored in current management measures in Brazil.

Keywords: Brazil, dusky-grouper, *E. marginatus*, small-scale fisheries.

Introduction

Several small-scale fisheries are pursued off the Atlantic Forest coast of Brazil (Begossi, 2008). The fishermen depend on these fisheries for their livelihood. Reef fishes are especially valued as food and in the commercial catch (Begossi et al., 2011a).

The dusky grouper [garoupa, *Epinephelus marginatus*(Lowe, 1834)] is a protogynous hermaphrodite reef fish. It is found in the eastern Atlantic Ocean, including the coast of southern Brazil, as well as in the Mediterranean Sea (Marino *et al*., 2000). In Brazil, *E. marginatus*is targeted by small-scale fishermen who sell their catch of this species in the local fish market at relatively high prices (Begossi & Silvano, 2008). Nevertheless, *E. marginatus*is considered threatened and classified as endangered on the IUCN red list(http://www.iucnredlist.org/apps/redlist/search). Moreover, sufficient information is not available on the catches made by the fisheries or on the biology or the ecology of this species and its congeners in Brazil, except for the studies of Andrade *et al*. (2003)and Gibran (2007) in the southeastern and southern coasts of Brazil. Other studies have reported information on the grouper *E. itajara*(Gerhardinger et al. 2006, 2009).

This study was performed in the southeastern Brazilian coast in the region of Paraty, Rio de Janeiro State. It complements previous studies on catches from small-scale fisheries conducted in the small-scale fishery of Copacabana (Rio de Janeiro) and in Bertioga (São Paulo State) (Begossi and Silvano, 2008). The purpose of the study was to obtain information on this threatened species (*E.marginatus*) and to make suggestions for its management in the coastal small-scale fisheries of Brazil and other similar tropical regions. As part of a major project on the Paraty fishery (Begossi et al., 2011b), we included a specific study on groupers at three landing points and/or fish markets: the Peixaria S. Pedro, an important fish market in the city of Paraty; the Pescados Sinésio, a fish store located at Praia Grande;and the Peixaria Lara, a fish store in Tarituba; For a map and more information on the research projects and the area, see http://umanitoba.ca/institutes/natural_resources/nri_cbrm_stud_ip_collaborators.html

The data collected on the *E. marginatusspecimens* examined included the weight, length (total), qualitative information on the stomach contents, and a macroscopic analysis of the gonads to verify the presence of visible sperm or the occurrence of visible eggs. The gonads were weighed (volume, ml). The stomach contents were analyzed qualitatively. These methods have been used in previous studies of grouper (Begossi & Silvano, 2008), snook(*Centropomus* spp.),(Begossi, 2008), and bluefish (*Pomatomus saltatrix*) (Silvano and Begossi 2010).

Our results were obtained from 220 groupers caught by fishermen and collected at the three above mentioned landing points in Paraty from May 2010 to April 2011 (Table 1). Spring (September-December) is the main fishing season of groupers, thus being the best period for collecting groupers from fishermen.

One-half of the grouper stomachs analyzed in this study were empty. Crabs represented 35% of the contents of the non-empty stomachs. The crab species found in the grouper stomachs included *Cronius ruber* and members of the genera *Pilumnus* and *Mitbrax* (Table 2). *C. ruber* is an important prey species found in the stomach contents of *E.marginatus* from Copacabana, Rio de Janeiro (Begossi & Silvano, 2008).
Most *E. marginatus* were caught among the islands of Paraty bay (islands at which 10 or more groupers were caught: Algodão Island= 26, Ventura I.=19, Araújo I.=10) or in areas relatively far from the coast (Joatinga Point= 25, Ponta Negra P.= 13). At Tarituba, on the coast, 29 groupers were caught.

Most groupers were caught by small-scale fishermen and had a total length of less than 50 cm (Figure 1).Visible eggs were

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not observed neither visible sperm. The volume of the gonads ranged from 0.5 ml (the most common value) to 2.5ml. All of the gonads observed were very small and translucent.

A comparison of our findings with other information collected from the small-scale fisheries of Copacabana (Rio de Janeiro city) and Bertioga (São Paulo coast) (Begossi and Silvano, 2008) shows similar results. *E. marginatus* are caught at early ages, small lengths, and in immature stages or before the age of first maturity. According to Marino *et al*.(2000),the females of *E. marginatus* from the Mediterranean area first reach sexual maturity at an estimated mean length (SL- standard length) of 43.8 cm. Andrade *et al.* (2003) found in the southern Brazil the first maturation length as 47 cm (TL – total length) for females of *E. Marginatus* and a period of spawning in the summer.The results shown here, of catches of groupers by small-scale fisheries, suggest possible recruitment overfishing(Sadovy, 1996) of *E. marginatus* in the studied region, which is indicated by the presence of especially immature individuals in landings Protogynous stocks, such as *E. marginatus*, may be far more vulnerable to fishing compared to other stocks (Andrade *et al*., 2003).

In Brazil, other species of the genus *Epinephelus*, such as *E.itajara* and *E. niveatus*, are subject to fishing restrictions imposed by the government through a mechanism called *defeso.* (http://www.mpa.gov.br/mpa/seap/Jonathan/mpa3/pesca/docs/Defeso-MARINHO-SEPOP-18-out-2011.pdf).

The *defeso* system is a closed fishing season during the reproductive period of the targeted species, which may include compensatory arrangements to fishermen, as in the case of the shrimp *defeso* (Begossi et al., 2011b). In the Mediterranean area, diverse mechanisms are used to protect *E. marginatus* (such as MPAs) where reproductive sites are relatively known (Bodiliset *al*., 2003; Bouchereau *et al*., 1999; Francour *et al*., 2001).

We suggest a procedure that we consider urgently needed for the management and conservation of *E. marginatus* in Brazil. To succeed, the management arrangements must address the following constraints and tradeoffs:

a) E. marginatus is a very important commercial fish caught and sold by small-scale fishermen who depend on the earnings from fish catches to sustain their livelihoods; for this reason, mechanisms to encourage the fishermen to participate in the protection of this species are required to develop a successful management program(Begossi *et al*., 2011b).

b) Mechanisms already exist in the Brazilian legislation to protect other target commercial species. These mechanisms include a *defeso* for other species of *Epinephelus*. Through the *defeso* system, fishermen can be compensated in the form of a payment for an environmental service (Begossi *et al*., 2011b): therefore, fishermen could receive a wage in the periods during which catches of *E. marginatus* will be forbidden. A suggestion would be to prohibit catches in the spring and summer (for example, months of December-February), a period during which landings of *E.marginatus* were abundant and other fish species targeted by small-scale fishermen in the region, such as snook, show reproductive activity. However, the period and duration of the defeso of *E. marginatus* should be negotiated with local fishermen and it could be longer than that currently adopted for the shrimp. Our proposed approach involves a co-management process between small-scale fishermen and the government authorities in which a *defeso* system for *E. Marginatus* is organized and small-scale fishermen are compensated for their losses to encourage their participation in conservation.

c) Marine protected areas (MPAs), or areas closed to fishing, have been useful to protect target reef fishes, including serranids, such as the coral trout (*Plectropomus* spp.) in Australia (Evans & Russ, 2004), and the *Mycteroperca bonaci* in the northeastern Brazilian coast (Francini-Filho &Moura, 2008). MPAs may also provide indirect and future benefits to surrounding fisheries, if adult fish protected inside the reserve moves out of its boundaries, or if larvae produced in the reserve are dispersed elsewhere (Gell& Roberts, 2003). However, MPAs are not a panacea, their efficacy depends on scientific ecological information available and this measure may elicit serious conflicts with local fishermen (Sale*et al*., 2005). In the studied region (Paraty bay) there is a MPA (Estação Ecologica dos Tamoios), but it has been created in a top-down fashion and had caused intense conflicts with local fishermen (Begossi *et al*., 2011b). Furthermore, such MPA was not defined following ecological criteria aimed at reef fish conservation. Therefore, the existing MPA design should be improved, including concerns to protect target reef fish, such as *E. marginatus*, consultation with local fishers, and an integrated management approach that links MPA, compensation schemes and closed fishing season (*defeso*).

Acknowledgements

We are very grateful for FAPESP and IDRC grants (# 2009/11154-3 and # 104519-004, respectively), which permitted our research in the Paraty area. We are very grateful to fishermen and to fish store owners, especially to William (Peixaria S. Pedro) and Sinésio(Pescados Sinésio), among others. Two authors (AB and RAMS) acknowledge productivity scholarships from CNPq.

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Figure Legend

Figure 1. Weight and length of dusky grouper, garoupa, *E.marginatus*, collected in Paraty, RJ, Brazil, from small-scale fishery landings at Praia Grande and Tarituba.

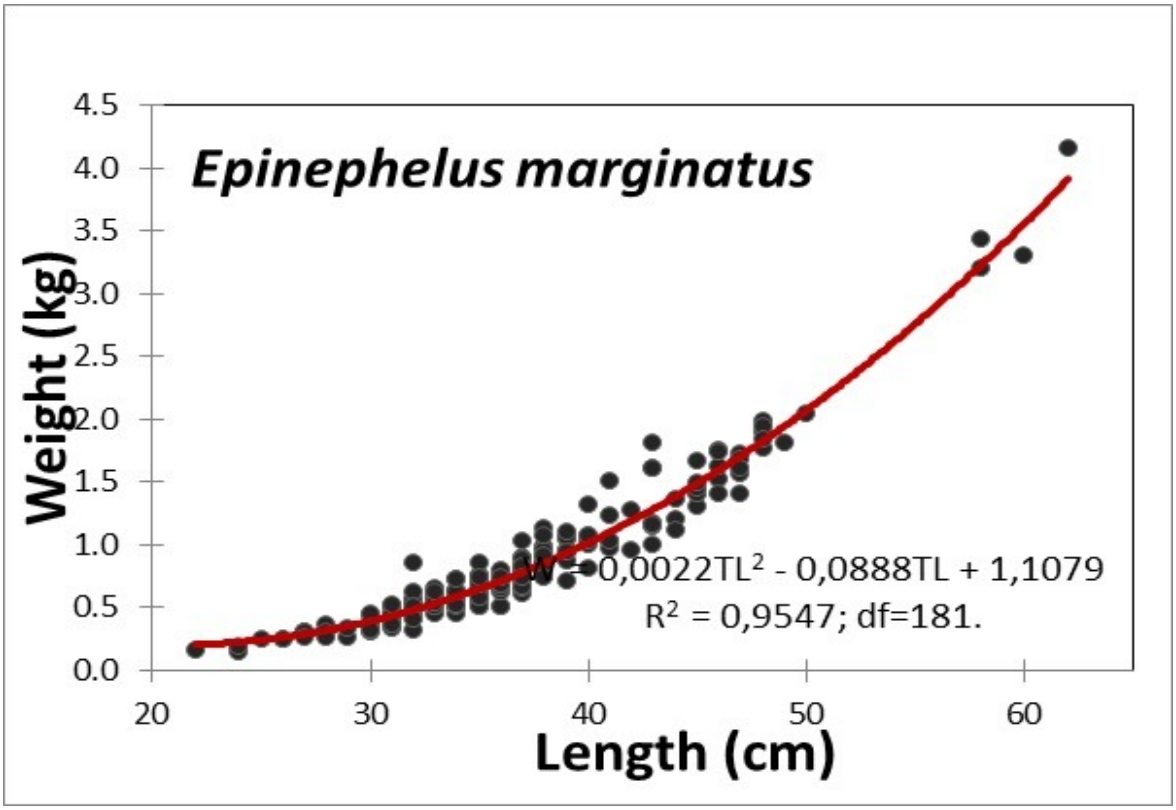

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Table 1. E. marginatus collected from small-scale fishing in Paraty, RJ, Brazil(kg per season and per location) November 2009-April 2011 (n=220)

Local	Spring (Sep-Nov)	Summer (Dec-Feb)	Autumn Mar-May	Winter (Jun-Aug)	All seasons
Paraty	66.36	17.5	10.84	31.27	126.03
Praia Grande	1.89	11.9	0.3	1.3	15.39
Tarituba	9.75	1.8	4.5	6.7	22.75
Total	78	31.25	15.65	39.27	164.17

Table 2: Content of stomach of E. marginatus (Paraty, RJ, Brazil) in % (n=220 groupers)

	Paraty	Perequê	Praia Grande	Total
Crustacean*	32.58	0	41.86	35.91
Fish	15.15	100	20.93	18.18
Molluscs			1.16	0.45
Algae	0	0	1.16	0.45
Empty	57.58	0	51.16	54.55

**Cronius ruber* and species of *Pilumnus* and *Mitbrax*.

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